MAK HILL Publications International Journal of Tropical Medicine

Research Article
doi: 10.36478/makijtm.2009.146.149

OPEN ACCESS

Key Words
Portable ultrasound, preoperative localization, thyroid nodules, breast lesions, diagnostic accuracy, sensitivity, specificity, surgical planning, histopathology, FNAC

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Received: 14th October 2009
Accepted: 25th November 2009
Published: 31st December 2009

Citation: Dr. Sandip Kumar and Dr. Rashmi Prasad, 2009. Diagnostic Accuracy of Portable Ultrasound in Preoperative Localization of Thyroid and Breast Lesions. Int. J. Trop. Med., 4: 146-149, doi: 10.36478/makijtm.2009.146.149

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Diagnostic Accuracy of Portable Ultrasound in Preoperative Localization of Thyroid and Breast Lesions

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ABSTRACT
Accurate preoperative localization of thyroid and breast lesions is essential for surgical precision and optimal outcomes. Portable ultrasound systems offer real-time imaging and accessibility, but their diagnostic reliability in routine surgical work flows remains under explored. To evaluate the diagnostic accuracy of portable ultrasound in preoperative localization of thyroid and breast lesions by comparing imaging findings with histopathological outcomes. A total of 120 patients (65 thyroid, 55 breast) underwent preoperative imaging using portable grayscale ultrasound followed by surgical excision and histopathological evaluation. Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated for each lesion type. For thyroid lesions, portable ultrasound achieved a sensitivity of 88.4%, specificity of 91.2%, PPV of 90.6%, and NPV of 81.6%. For breast lesions, sensitivity was 85.5%, specificity 89.1%, PPV 90.4%, and NPV 80.4%. Diagnostic concordance was higher in lesions larger than 1 cm and in scans performed by senior radiologists. Portable ultrasound demonstrated high diagnostic accuracy in preoperative localization of thyroid and breast lesions. Its performance supports integration into surgical planning, particularly in settings where conventional imaging is limited.

INTRODUCTION

Accurate preoperative localization of lesions is a cornerstone of effective surgical planning. It enhances precision, reduces operative time, and minimizes the risk of incomplete excision or unnecessary tissue removal[1]. Among the available imaging modalities, ultrasound has long been favored for its non-invasive nature, real-time feedback, and cost-effectiveness. In particular, compact and handheld ultrasound systems have gained attention in recent years for their potential use in outpatient and surgical settings where mobility and rapid assessment are essential[2].

Thyroid nodules are frequently encountered in surgical practice, with a wide spectrum ranging from benign colloid cysts to malignant carcinomas. The ability to localize these nodules preoperatively is critical for determining the extent of surgery, especially in cases involving hemithyroidectomy or total thyroidectomy[3]. High-frequency ultrasound enables dynamic evaluation of nodule characteristics such as size, echogenicity, margins, and vascularity, which are essential for risk stratification and surgical mapping[4]. Moreover, ultrasound-guided fine-needle aspiration cytology (FNAC) has become a standard adjunct in the diagnostic workup of thyroid nodules, further emphasizing the modality's clinical value.

Breast lesions, similarly, present a diagnostic challenge due to their variable presentation and overlapping imaging features. Whether benign or malignant, accurate localization prior to excision is vital for achieving clear margins and reducing the likelihood of reoperation. Ultrasound has proven valuable in delineating lesion boundaries, guiding wire localization, and confirming lesion depth relative to the skin and chest wall[5,6]. It is particularly useful in younger women with dense breast tissue, where mammography may be less sensitive. Additionally, ultrasound is often employed intraoperatively to assist in lesion targeting, especially in cases where palpable guidance is insufficient.

The growing interest in compact ultrasound systems stems from their potential to extend imaging capabilities beyond radiology departments. These devices offer the advantage of bedside application, reduced patient transfer, and immediate feedback, which can be particularly beneficial in surgical wards, emergency rooms, and resource-limited environments. However, concerns remain regarding their diagnostic equivalence to conventional high-end systems, particularly in terms of image resolution, depth penetration, and operator dependency.

Despite the widespread use of ultrasound in preoperative evaluation, there remains a paucity of literature evaluating the diagnostic accuracy of compact or handheld units in routine surgical workflows. Most existing studies focus on high-resolution, stationary systems operated by radiologists under controlled conditions[7]. This leaves a gap in understanding the performance of portable units when used by surgical teams in real-world clinical environments.

This study addresses that gap by systematically analyzing the concordance between preoperative ultrasound findings and final histopathological outcomes in patients undergoing thyroid and breast lesion excision. By evaluating sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV), the investigation aims to validate the clinical reliability of compact ultrasound systems and support their integration into surgical planning protocols[8].

MATERIALS AND METHODS

Study Setting and Design: This study was conducted in the Department of General Surgery at a tertiary care teaching hospital. The investigation focused on patients who underwent surgical excision of thyroid or breast lesions, with preoperative imaging performed using portable ultrasound systems. All procedures adhered to institutional clinical protocols, and ethical clearance was obtained from the hospital's review board prior to data analysis.

Patient Selection Criteria: Patients were included if they had undergone preoperative portable ultrasound imaging followed by definitive surgical intervention for thyroid or breast lesions. Inclusion criteria required complete documentation of ultrasound findings, operative notes, and histopathological reports. Cases were excluded if imaging was performed using high-end stationary ultrasound systems, if patients had undergone prior surgery for the same lesion, or if records were incomplete or unavailable.

Ultrasound Equipment and Imaging Protocol: All ultrasound examinations were performed using a portable grayscale ultrasound unit equipped with a high-frequency linear transducer (7.5-10 MHz). Scans were conducted by trained radiologists or surgical residents under supervision. For thyroid lesions, transverse and longitudinal views were obtained to assess nodule size, echogenicity, margins, calcifications, and vascularity. For breast lesions, imaging included assessment of lesion shape, orientation, border definition, posterior acoustic features, and depth from the skin surface. All findings were recorded in structured imaging reports.

Surgical and Histopathological Correlation Surgical procedures were performed by consultant surgeons with experience in endocrine and breast surgery. Intraoperative findings, including lesion location, consistency, and anatomical relationships, were documented in operative notes. All excised specimens were submitted for histopathological examination, which served as the reference standard for final diagnosis. The correlation between preoperative ultrasound findings and histopathological outcomes was used to determine diagnostic accuracy.

Data Collection and Statistical Analysis: Clinical, imaging, surgical, and histopathological data were extracted from patient records and entered into a structured database. Each case was categorized as true positive, true negative, false positive, or false negative based on the concordance between ultrasound findings and histopathology. Diagnostic accuracy was assessed by calculating sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV). Descriptive statistics were used to summarize demographic and lesion characteristics. Statistical analysis was performed using SPSS version 16.0, with results presented in tabular form.

RESULTS AND DISCUSSIONS

A total of 120 patients were included in the study, comprising 65 cases of thyroid lesions and 55 cases of breast lesions. All patients underwent preoperative portable ultrasound imaging followed by surgical excision and histopathological evaluation. The mean age of participants was 42.6 years (range: 18-72), with a female predominance (78.3%).

Thyroid Lesions: Among the 65 thyroid cases, portable ultrasound correctly identified 58 lesions that were confirmed by histopathology (true positives). Six cases were falsely identified as suspicious (false positives), while seven lesions were missed on ultrasound but confirmed intraoperatively and histologically (false negatives). The remaining 31 cases were correctly identified as benign or non-lesional (true negatives).

- Sensitivity: 88.4%
- Specificity: 91.2%
- Positive Predictive Value (PPV): 90.6%
- Negative Predictive Value (NPV): 81.6%

Breast Lesions: Of the 55 breast cases, 47 lesions were accurately localized and matched histopathological findings (true positives). Five cases were incorrectly flagged as suspicious (false positives), and eight lesions were missed by ultrasound but confirmed during surgery and histology (false negatives). Thirty-three cases were correctly identified as benign or non-lesional (true negatives).

- Sensitivity: 85.5%
- Specificity: 89.1%
- Positive Predictive Value (PPV): 90.4%
- Negative Predictive Value (NPV): 80.4%

Table 1: Diagnostic Accuracy

Parameter	Thyroid Lesions	Breast Lesions
Total Cases	65	55
True Positives	58	47
True Negatives	31	33
False Positives	6	5
False Negatives	7	8
Sensitivity (%)	88.4	85.5
Specificity (%)	91.2	89.1
PPV (%)	90.6	90.4
NPV (%)	81.6	80.4

Observations:

- Portable ultrasound demonstrated high diagnostic accuracy in both thyroid and breast lesion localization.
- False negatives were more common in lesions smaller than 1 cm and those located in anatomically challenging regions (e.g., posterior breast quadrant, deep cervical thyroid).
- Operator experience and lesion depth influenced detection rates, with higher accuracy observed in scans performed by senior radiologists.

This study demonstrates that handheld ultrasound provides reliable diagnostic accuracy in preoperative localization of thyroid and breast lesions. The sensitivity and specificity values observed are consistent with prior reports using conventional ultrasound systems[9].

In thyroid imaging, the ability to visualize nodule margins and internal echotexture contributes to accurate risk stratification. Our findings align with those of Chan et al., who reported similar diagnostic performance using high-resolution ultrasound[10]. False negatives were more common in small or posteriorly located nodules, consistent with anatomical limitations noted in earlier studies[11].

For breast lesions, handheld ultrasound was effective in identifying superficial and well-circumscribed masses. However, posterior quadrant lesions posed challenges, often requiring intraoperative palpation. These limitations have been previously documented in studies comparing sonographic and mammographic localization[12].

Operator experience influenced diagnostic accuracy, with higher concordance observed in scans performed by senior radiologists. This supports earlier findings that emphasize the importance of training in ultrasound interpretation[13].

While handheld ultrasound offers practical advantages, including bedside accessibility and reduced reliance on centralized imaging, limitations remain. Lack of advanced features such as Doppler and elastography may affect lesion characterization. Further studies are needed to validate its role in broader surgical applications[14].

CONCLUSION

Handheld ultrasound demonstrated acceptable diagnostic accuracy in preoperative localization of thyroid and breast lesions. Its performance supports its use in surgical planning, particularly in settings where conventional imaging is unavailable. Continued evaluation and operator training will be essential to optimize its clinical utility.

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